DOCUMENT RESUME

ED 021 995 VT 004 359

By- Brozen, Yale
AUTOMATION, THE IMPACT OF TECHNOLOGICAL CHANGE.
American Enterprise Inst. for Public Policy Research, Washington, D.C.
Pub Date Mar 63
Note- 54p.
Available from- American Enterprise Institute, 1200 Seventeenth Street, N. W., Washington, D. C. 20036 ($1.00)
EDRS Price MF- $0.25 HC- $2.24
Descriptors- *AUTOMATION, ECONOMIC FACTORS, *ECONOMIC PROGRESS, EMPLOYMENT, SOCIAL FACTORS, *TECHNOLOGICAL ADVANCEMENT, UNEMPLOYMENT

The scale of educational activities is increasing because mechanization, automation, cybernation, or whatever new technology is called, makes it possible to do more than could formerly be done. If a man helped by an automatic machine can turn out twice as much per hour, then, presumably, only half as many hours of work will be available for each man, or only half as many jobs. The President of the United States has said that approximately 1.8 million persons holding jobs are replaced every year by machines. Thus, presumably, 18 million persons lost their jobs in the 1950's because of machines, yet total employment rose. In fact, it could be said that technological change has created more jobs than it has destroyed. While 13 million jobs were destroyed by various causes in the 1950's more than 20 million were created as a result of technological change and growth in the stock of capital. Automation should be welcomed rather than feared. The rate of automation depends on the availability of capital and the rapidity in the rise in real wage rates. The unemployment problem is not the result of automation and will not be worsened by automation. This new, and old, technology is spreading very slowly, and the present slow pace is not likely to accelerate. (HC)

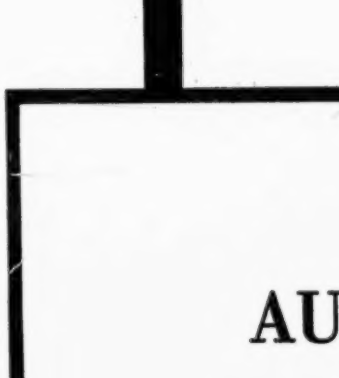
C1

AUTOMATION

THE IMPACT OF TECHNOLOGICAL CHANGE

By
YALE BROZEN

ED021995



VT004359

AMERICAN ENTERPRISE INSTITUTE
FOR PUBLIC POLICY RESEARCH

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

AUTOMATION

THE IMPACT OF TECHNOLOGICAL CHANGE

By
YALE BROZEN

PUBLISHED AND DISTRIBUTED BY THE
AMERICAN ENTERPRISE INSTITUTE
FOR PUBLIC POLICY RESEARCH
WASHINGTON, D.C.

March 1963

"PERMISSION TO REPRODUCE THIS
COPYRIGHTED MATERIAL HAS BEEN GRANTED
BY American Enterprise Institute for Public Policy Research
TO ERIC AND ORGANIZATIONS OPERATING
UNDER AGREEMENTS WITH THE U.S. OFFICE OF
EDUCATION. FURTHER REPRODUCTION OUTSIDE
THE ERIC SYSTEM REQUIRES PERMISSION OF
THE COPYRIGHT OWNER."

Automation: The Impact of Technological Change is one of a series of AEI studies in the general areas of inflation and economic growth. This study was supported by funds received from The Kresge Foundation.

© 1963 American Enterprise Institute for Public Policy Research. 1012 14th Street, N.W., Washington 5, D. C. All rights reserved under International and Pan-American Copyrights Conventions.

Library of Congress Catalog No. 63-13395

Price: $1.00

AMERICAN ENTERPRISE INSTITUTE
For Public Policy Research

THE AMERICAN ENTERPRISE INSTITUTE FOR PUBLIC POLICY RESEARCH, established in 1943, is a nonpartisan research and educational organization which studies national policy problems.

Institute publications take two major forms:

1. LEGISLATIVE AND SPECIAL ANALYSES—factual analyses of current legislative proposals and other public policy issues before the Congress prepared with the help of recognized experts in the academic world and in the fields of law and government. A typical analysis features: (1) pertinent background, (2) a digest of significant elements, and (3) a discussion, pro and con, of the issues. The reports reflect no policy position in favor of or against specific proposals.
2. LONG-RANGE STUDIES—basic studies of major national problems of significance for public policy. The Institute, with the counsel of its Advisory Board, utilizes the services of competent scholars, but the opinions expressed are those of the authors and represent no policy position on the part of the Institute.

ADVISORY BOARD

PAUL W. MCCRACKEN, *Chairman*
Professor, School of Business Administration, University of Michigan

KARL BRANDT
Director, Food Research Institute
Stanford University

MILTON FRIEDMAN *
Professor of Economics
University of Chicago

GOTTFRIED HABERLER
Professor of Economics
Harvard University

ARTHUR KEMP
Professor of Money and Credit
Claremont Men's College

FELIX MORLEY
Editor and Author

STANLEY PARRY *
Professor of Political Science
University of Notre Dame

ROSCOE POUND
Professor Emeritus
Harvard University

E. BLYTHE STASON
Dean Emeritus
University of Michigan Law School

*On leave 1962-63 academic year.

OFFICERS

CARL N. JACOBS—*Chairman*
WALTER C. BECKJORD—*Vice Chairman*
HENRY T. BODMAN—*Vice Chairman and Treasurer*
H. C. LUMB—*Vice Chairman*
WILLIAM J. BARODY—*President*

TRUSTEES

HENRY W. BALGOOYEN
WALTER C. BECKJORD
HENRY T. BODMAN
HARRY L. BRADLEY
JOHN M. BRILEY
ROBERT P. BURROUGHS
FULLER E. CALLAWAY, JR.
WALLACE E. CAMPBELL
L. M. CASSIDY
J. D. STETSON COLEMAN
CLYDE T. FOSTER
HARRY C. HAGERTY
WALTER HARNISCHFEGER
JOHN B. HOLLISTER
CHARLES R. HOOK
ROBERT A. HORNBY
N. BAXTER JACKSON
CARL N. JACOBS
EDWARD H. LITTLE
RAYMOND S. LIVINGSTONE
FRED F. LOOCK
H. C. LUMB
WILLIAM L. MCGRATH
GEORGE P. MACNICHOL, JR.
ALLEN D. MARSHALL
H. S. MIDDENDORF
DON G. MITCHELL
PETER O'DONNELL, JR.
HARVEY PETERS
H. LADD PLUMLEY
EDMUND W. PUGH, JR.
PHILIP A. RAY
HERMAN J. SCHMIDT
E. LEE TALMAN
WILLIAM T. TAYLOR
R. C. TYSON
ERRETT VAN NICE

THOMAS F. JOHNSON
Director of Research

JOSEPH G. BUTTS
Director of Legislative Analysis

Contents

INTRODUCTION 1
Historical Perspective 2
The Pace of Automation 3
Automation and Unemployment 5

VARIETIES OF AUTOMATION 10
Automation as Adaptation 11
Automation Resulting from Invention 13

SHORT-RUN ADAPTATION TO AUTOMATION 19
The Magnitude of Displacement 20
The Location of Displacement 22
Methods for Minimizing Displacements 24

LONG-RUN ADAPTATION TO AUTOMATION 27
The Shift in the Structure of Industry and Employment... 28
The Shift in Occupational Structure 32
Small Versus Large Business 34

CONCLUSIONS 37

APPENDIX 40

SELECTED BIBLIOGRAPHY 44

• • •

AEI PUBLICATIONS 45

Automation is not a device with which to outlaw, displace or dispense with man. . . . It is a means for increasing man's stature and extending his ability to produce in greater volume with less physical effort or mental strain.

F. G. Woollard, *Machines in the Service of Man*

AUTOMATION

THE IMPACT OF TECHNOLOGICAL CHANGE

INTRODUCTION

WORRIES ABOUT AUTOMATION have made headlines, occupied congressional committees, been the subject of many conferences, and produced a deluge of reports. The name is new, but the condition and the fear are old. In the 1920's, mechanization and electrification were felt to threaten us. In the 19th century, the Luddites rioted and smashed equipment because of their fear of the steam engine and power machinery. In the 15th century, hostelers and innkeepers opposed the growing use of the stage coach. In the 12th century, hand fullers dreaded the spread of mechanical fulling.

The worries about automation are mixed. Some fear that it is not coming rapidly enough to solve our balance-of-payments and economic growth problems. Others fear it is spreading with such a rush that workers are unable to learn new skills rapidly enough to avoid becoming as obsolete as horses.

Historical Perspective

Before looking at the specifics of this decade's problem, we should place automation in the perspective of the continuing stream of history. Although the techniques now being applied are the result of an engineering revolution, they are, in an economic and cultural sense, nothing more than a continuation of an evolution that has been going on for centuries. Beginning with a world in which men could barely gather and capture enough to keep themselves alive, we went through a first technological revolution, ending about 3000 B.C. It raised productivity sufficiently that societies could afford priests, an aristocracy, armies, and a bureaucracy. We even reached the stage of the Greek democracies. These were democracies of the few, however, resting on a large class of slaves.

The second technological revolution did away with slavery, since it became cheaper to use mechanical power than human muscle, and created the base on which mass democracy now rests. The economic gains of the first revolution went to the few; those of the second have gone to the many; perhaps the automation revolution will carry us on from a mass democracy to a mass aristocracy.

In the past quarter century, we have doubled the productivity of the average man. If we can do the same in the next quarter century, average family income will go to $14,000 a year instead of the present $7,000. Median educational attainment, which rose from the grade school graduate to the high school graduate level, will move to that of the junior college graduate. Similar movements in the availability of leisure, the consumption of world travel, music, fine art, and medical services, will occur

if productivity and income trends continue. Essentially, this is what automation promises.

The Pace of Automation

Technology is felt to have moved at a sedate pace in the past compared with the recent rate of advance. In the 1930's, it was fashionable to argue that the country was stagnant because, among other factors, technology was not producing the great new techniques it formerly did. For this reason, it was said, there was little use for additional capital. Unemployment then was attributed to the lack of technological advance and the resultant lack of outlets for the application of new capital.

Too much technological change, however, may be as bad as too little. In the late 1940's, we were told that automation was coming with such speed that factories would be fully automated in 10 to 20 years and that we were faced with "a decade or more of ruin and despair." It is more than 12 years since that forecast was made by Norbert Wiener, the popularizer of the term "Cybernetics" and one of the developers of the mathematics of communication which underlies much of the new control technology. Yet, we still employ over 12 million production workers in factories, about the same number as at the time of Wiener's prediction. Total employment in manufacturing industries has grown by more than a million men since 1950.

How rapidly we automate depends upon the availability of capital and the rapidity of the rise in real wage rates. Present rates of capital formation are not much higher than the amount required to equip additions to the work force with the same quantity of capital as that used by the presently employed work force. If we add 1,300,000 workers a year to our labor force, the rate forecast for the next decade, nearly $20 billion a year will be needed to equip them sufficiently to be productive enough to be employable at current wage rates. If wage rates increase, a larger amount of capital will be required. If a larger amount does not become available in this situation, unemployment will grow.

Total spending on business plant and equipment is less than $40 billion a year. Almost half of this amount is required to replace plant and equipment worn out by use, rendered economically obsolete, and destroyed by fire or other catastrophe. There is very little left to increase the quantity of capital per man employed after providing for additions to the work force. In these circumstances, the spread of automation will be slow.

Automation is spreading somewhat more rapidly than is indicated by these figures because of the overpricing of labor in some industries. Increases in wage rates make it economic to automate when it otherwise would not be so. The cost of the new equipment required to replace a man is about $35,000. If the annual wage of a man is less than $7,000, it does not pay to replace him at this cost since property and corporate earnings taxes, insurance, depreciation, and interest costs amount to about $7,000 on $35,000 worth of equipment. If annual employment costs rise above $7,000, it then pays to replace a few men. The rate at which men will be released by an industry to other occupations or to the manning of additional capacity depends upon how rapidly wage rates rise. (If they rise too rapidly, men will not be completely absorbed by expanding occupations and unemployment will rise.)

As men are replaced, it becomes increasingly expensive to replace additional men. In the late 1940's, when coal mining employment exceeded 400,000, the cost of replacing a man was about $20,000. Now that coal mining employment has dropped below 170,000, the cost of replacing a man is close to $50,000.

To automate as completely as possible with present technology, only one major segment of the American economy, manufacturing, would require an expenditure of well over $2.5 trillion, assuming output is not increased. Even to modernize manufacturing to the levels of the new plants built in the 1950's would require over $500 billion. Since total spending on new plant and equipment in manufacturing amounts to about $15 billion per year, American manufacturing could not be mod-

ernized even to the level of the technology of the 1950's for over 30 years. And this is under the extreme assumption that all the expenditure is used for modernization and none for expansion. With the current division of capital outlays between modernization and expansion, modernization to the level of new plants of the variety built in the 1950's would require about 50 years.

To automate completely manufacturing industry with no increase in total output would require two centuries at current rates of modernization. If we expand output at the rate necessary to keep up with population growth, however, present rates of capital formation will never result in complete automation of manufacturing unless the cost of automation is reduced to less than one-sixth of its present expense. That is unlikely to occur within the foreseeable future.

Judging by changes in productivity, the recent pace of technological change is no greater than in the past and is slowing. In manufacturing, output per man-hour rose by 2.9 percent per year from 1947 through 1961. The rise was more rapid in the earlier part of the period than in the latter. It averaged 3.2 percent per year from 1947 through 1953. Since 1953, the average rate of rise has dropped to 2.7 percent.

Output per man-hour in manufacturing rose much more rapidly in the 1920's than in the last decade. The rate of increase was 5.3 percent per year, a rate almost double that of the 1950 decade. Automation is proceeding more slowly, in terms of its effect on productivity, than earlier technological change.

Automation and Unemployment

There are observers who argue that automation or cybernation is something more than the latest stage in the long evolution of technology. Automation is said to be so different in degree that it is profoundly different in its effect. Automated machines controlled by computers do not simply augment muscle power, but replace and outperform human intelligence. In the future, ma-

chines will not only run machines; they will repair machines, program production, run governments, and even rule men. Union leaders will collect no dues and business will have no customers because, presumably, there will be no production workers required. Human beings will be made as obsolete by these superior machines as horses were by the tractor and the automobile.

Although we may grant that automation differs from other kinds of technology, we should not blind ourselves to history to the point of saying it is completely new. Perhaps the earliest automated device was the pressure cooker invented by Denis Papin in 1680. He originated a pressure control, which is still one of the simplest and most widely-used regulators today.[1]

During the 18th century, several types of automatic regulators were applied to windmills. An automatic, card-programmed loom was devised by Jacquard over 150 years ago. An automatic flour mill was built in 1784. Automatic silk looms were designed by Jacques Vaucanson in 1741. Eighteenth century steam engines were controlled by governors which had the sensing, feedback, and resetting characteristics which are the hallmark of automation. And despite increasing automation in the last two centuries, employment continually rose.

In terms of a very recent type of automation, the use of electronic data processing equipment, a United States Department of Labor study of large firms which introduced such equipment concluded that:

> Despite the reduction in labor requirements for the tasks performed by the computers, total employment of the offices as a whole rose. Over the 4 years from December 1953 to December 1957, total office employment at 17 of the offices studied increased an average of 7 percent. This increase, however, was less than the 15 percent rise reported for clerical and kindred workers in the Nation as a whole. In 6 of the 17 offices, the increase was greater than 15 percent; in 7, less; and in 4 there was a decrease. Although the immediate effect of electronic

[1] R. H. Macmillan, *Automation* (Cambridge: Cambridge University Press, 1956).

> data processing suggests some retardation in the growth of office employment, particularly part-time work, the experience of some offices suggests the possibility of expanding employment in new areas of office activity to handle information which had previously been uneconomical to acquire.[2]

We know from experience that automation in the factory turns machine operators into machine tenders and maintainers. This has already occurred in the textile industry, to name one example. Upon walking into the loom room of a modern mill, the first impression is that of a vast space filled with busy machinery and no people in sight. Yet employment in textile mill products exceeds 900,000. The chemical and petroleum refining industries use automatically controlled, continuous processes. They, too, provide employment on large scale amounting to more than one million jobs.

The effect of automation has been to increase the relative number of maintenance men, engineers, office employees, production control specialists, and other non-machine operators that are required. This is simply a continuation of a trend which has been going on for decades. In 1899, less than 7 percent of the manufacturing industry labor force consisted of persons other than production workers. Today, 25 percent of manufacturing employees are indirect workers. Since 1940, production worker employment in manufacturing has increased by 52 percent while other workers increased by over 100 percent.

The primary effect of automation is not a reduction in the number of jobs available. Rather, it makes it possible for us to do many things which otherwise could not and would not be done. It will, in the future, literally make it possible to travel to the moon. It has, through the aid it gives doctors, saved lives that otherwise would be lost. By controlling traffic signals in response to traffic flows and reducing traffic congestion, it has added hours to the free time of commuters every week. It has helped

[2] U.S. Bureau of Labor Statistics, *Adjustment to the Introduction of Office Automation,* Bulletin No. 1276 (Washington: U.S. Government Printing Office, 1960), p. 4.

scientists, with the aid of high-speed indicators, to develop new knowledge that would not have been available in our lifetimes. We are increasing the scale of educational activities because mechanization, automation, cybernation, or whatever we choose to call our new technology, makes it possible to do more than we could formerly. With the coming of automation, men are able to do more and have more. Both sublime and mundane activities are being enlarged.

Those who fear a great rise in unemployment think in terms of a given list of goods to be produced. If a man helped by an automatic machine can turn out twice as many widgets per hour, then, presumably, only half as many hours of work will be available for each man to do or only half as many jobs. The President of the United States has said "that approximately 1.8 million persons holding jobs are replaced every year by machines." Presumably, 18 million persons lost their jobs in the 1950's because of machines; yet, total employment rose by seven million.

Using the above logic, there would be more jobs now if productivity had not increased. It would take nearly two million more men to turn out our present production if our productivity were at the 1961 level. Reducing this to absurdity, if we froze productivity at the 1952 level, it would take 17 million more men to produce our present output. Unemployment then, would be minus 13 million, obviously an impossibility.

Technological change enables us to do more than we could otherwise. It enables us to pay men more and, at the same time, provide more jobs. It enables us to improve our housing, enrich our diets, provide better medical services, educate ourselves to higher levels, as well as making it possible to explore space.

Those who are concerned about unemployment should welcome rather than fear automation. If it were not for the technical advances of the past decade, unemployment, at present wage levels, would be above the astronomical levels of the early 1930's. Alternatively, if real wage rates were at levels consistent

with full employment under the same technology as that practiced in 1950, wage rates would be about $10.00 per week lower than they are now.

Technological change has created more jobs than it has destroyed. The number of civilians at work in 1961 was seven million higher than ten years before. Technological change and the growth in our stock of capital (in the form of plant and equipment and in the form of investment in raising the educational level of our population) created over 20 million jobs in the fifties, and about 13 million jobs were destroyed by various causes. The 20 million new jobs created and the 13 million jobs destroyed left a net gain of seven million positions.[3]

[3] See Appendix for an illustration of the relationships involved.

VARIETIES OF AUTOMATION

WHILE THE LONG-RUN RESULTS of automation may be the desirable effects noted previously, what will occur in the transition period—the short run? Will workers find it necessary to change jobs and to learn new skills? Will they suffer displacement at best and unemployment at worst? Will some regions be depressed while others boom? Will some of us enjoy increasing prosperity while a growing number suffer unemployment? Will small businesses wither while giant corporations flower?

Automation is not a simple phenomenon whose results can be categorized on the basis of "if automation, then this consequence." The effects of automation differ depending upon the type of automation and the forces leading to its application. To understand what is happening, and what will happen, we must use several categories and examine characteristic varieties.

Automation as Adaptation

Much of the automation going on in the American economy is an adaptive response to changing prices of labor and capital. As we increase the stock of capital, productivity rises and wage rates increase. As wage rates rise, it pays the individual firm to shift to more capital intensive techniques which were not previously economic. From the point of view of a single business, the wage rise makes the shift economic and often forces it. From the point of view of the nation, the rise in the quantity of capital makes the shift possible and desirable.

"Detroit automation" typifies this variety of technological change. It is little more than carrying automatic manufacture a step further by the use of transfer equipment to move work from one automatic machine tool to another and interlocking these tools to get high utilization. The technique was first used in 1927 by Morris Motors of England. The method was technically, but not economically, successful at that time.

Since 1927, wage rates have risen and machine tools have become more expensive. Now that real hourly wage rates have more than doubled their 1927 level, the saving of direct labor costs in operating machinery and transferring work and the saving of labor in building machine tools is sufficient to justify the investment in transfer equipment and interlock controls.

When the Ford Motor Company began applying "Detroit automation," it primarily took the form of a larger quantity of capital applied with its current labor force to turn out larger amounts of work. Despite the saving in machine tool investment made possible by increasing utilization from 65 to 80 percent,

there was an overall increase in capital requirements of about 25 percent in the Cleveland engine plant, where the technique was applied. There was a decrease of 22 percent in the direct labor force required to operate machinery, but this was more than 50 percent offset by the rise in maintenance personnel required with the new arrangement. Total man-hours used in the company rose, partly because of a rise in output, partly because more man-hours were used per automobile to turn out a more complicated product.

Automation of the Detroit variety, resulting mainly from a rise in wage rates, has different consequences depending upon the cause of the wage rate rise. If the rise is forced by an increased demand for labor on the part of other industries (as a consequence, let us say, of an increased supply of capital), any economies in the use of labor by the auto industry which decrease its use of people, will not result in unemployment. Insofar as auto wage rates rise to prevent an unwanted loss of labor to other industries, those who do leave consist of men taking jobs elsewhere. Joblessness among the people leaving the industry does not occur since they are being bid away by rival employers.

If wage rates in an industry are increased by raising floors set by minimum wage laws (such as the Fair Labor Standards Act), by administrative action (such as under the Walsh-Healy Act and the Davis-Bacon Act), or by negotiated agreements between employers and unions, the employment results may be different. To the extent that higher rates result from these actions than those which would be set in free markets, the resulting automation will release manpower to inferior alternative uses. The released men may either remain unemployed or move to less productive, lower paid alternative jobs.

An example of the unemployment caused by arbitrarily determined wage rates, which is attributed to automation, is the case of elevator operators in Chicago. There is a high incidence of unemployment among male juveniles in Chicago. Many of these boys would be happy to accept jobs as elevator operators

at $1.00 to $1.25 an hour. The elevator operators union imposes a minimum wage of $2.40 an hour, however, for operators in downtown Chicago buildings. Owners of buildings find it economic to spend $40,000 per elevator to automate their lifts and make them self-operating in these circumstances. Since the taxes, insurance, depreciation, maintenance, and interest cost of automating an elevator amount to $8,000 per year, it did not pay to automate when two shifts of operators cost only $5,000 per year. The union has driven the two shift cost of operation to over $10,000 per year. The result is elevator automation, a drain of capital from expansion of production where it would provide more jobs, fewer jobs for elevator operators, and problems of unskilled teenagers finding tasks to keep themselves occupied.

Thus adaptive automation has differing employment consequences. The specific result depends upon the forces leading to the increases in wage rates which cause the adaptation.

Automation Resulting from Invention

In the preceding section, the type of automation discussed required additional capital which was used to replace labor. Such capital was too expensive to use to replace labor at lower wage rates. The techniques were known, but they were not applied until wage rates rose to the point where it became cheaper to perform jobs with more machines and less men. Unemployment occurred only if wage rates were pushed above free market levels by governmental or union actions or if employers made mistakes in setting wage rates.

Another type of automation is that which occurs as a result of a new invention without any preceding change in employment costs relative to capital costs. A new technique which does a given job with less labor and less capital will be applied without waiting for an increase in wage rates. Railroad classification yards using computer controls installed in recent years are of this character. The Conway yard now in operation on the Pennsylvania Railroad illustrates this category of automation.

An investment of $34 million was made at Conway, Pennsylvania, and nearby points to automate the classification of freight cars. Because of the more rapid handling of cars with this facility, it saved the equivalent of 13,000 freight cars. The same amount of freight can now be moved with $100 million less investment in rolling stock. The *net* saving in capital investment in railroad equipment as a result of this one facility amounted to nearly $70 million and labor savings equivalent to 200 men occurred.

But it should be kept in mind that the lower employment in the railroad industry *required to move a given amount of freight* as a result of this type of automation does not necessarily mean lower employment in the railroad industry. If it does result in less railroad employment, it still does not mean lower employment in the nation.

The employment effect in the railroad industry depends upon the change in the price and quality of freight service and the response in the rate of buying of rail freight service to the change in price and quality. Freight service is improved by virtue of an eight-hour saving in the time required to move freight cars from either end of the Pennsylvania system to the other (between New York and Chicago, for example). The savings in labor and capital requirements mean a lower price for freight service than would otherwise prevail. If electronic classification yards save 1 percent of the rail manpower required to move a given volume of freight, but increase the amount of freight business done by railroads by 1.5 percent, the net result is a one-half of 1 percent increase in rail employment.

If rail freight business is not very responsive to price and quality changes, perhaps freight volume will be only three-fourths of 1 percent higher than it otherwise would be. In this instance, under the above assumptions, a one-fourth of 1 percent decline in rail employment will occur. Under the circumstances of this type of automation, no increase in the nation's unemployment need occur, however.

The investment in the Conway yard displaced 200 men and released $70 million in capital. If volume of freight service increased by the amount assumed in the preceding paragraph, 150 men and approximately $5 million in capital would be reabsorbed in other railroad departments. A net displacement of 50 men would occur along with the release of over $60 million of capital. The additional supply of capital made available to other industries would increase the number of jobs available by about 500. This figure is based on the relations prevailing in the past decade. In general, we can expect a little more than half the capital becoming available to be used for modernization (for economizing on labor and materials) and less than half for expansion. Approximately one man is released for each $35,000 of modernization investment and one man is required for each $16,000 or $17,000 of expansion investment.

In terms of the recent proportions in which capital has been used, the released $60 million will be used to pay for $35 million of modernization and $25 million of expansion. Modernization of this extent will release about 1,000 men and expansion of this amount will require 1,500 men. The net increase of 500 jobs outside the rail industry can absorb the 50 men released by the construction of a Conway Yard and 450 additional. The net result of this type of automation, thus, is decreased unemployment despite lower rail employment.

Another category of newly invented automation is that which saves labor but no capital. The consequences in this case depend upon the responsiveness of the rate of demand to a change in price in the affected industry. A new technique which exemplifies this is the development of the automatic method for machining cylinder heads. The old method required six operators and six machines costing $240,000. The new machine cost $230,000 and required only one operator to turn out the same amount of product. Inasmuch as the old machines, in this case, could be sold for $60,000 in the second-hand market, it paid to replace the old machines at the prevailing wage levels at a net invest-

ment requirement of $170,000. The wages saved on the five men released made the investment worthwhile.

The lower prices made possible by less expensive methods of production such as that described above, frequently create a sufficient increase in the rate of product demand to require more employees in the industry. Also, the greater income resulting from the effect of technical advance in raising productivity increases the demand for many products and services and increases employment opportunities (see Table I).

Some industries have, however, found that the rate of demand does not increase sufficiently to maintain employment. In this case, men are released who must find employment elsewhere. At the same time, these industries absorb capital. This reduces the flow of new capital available to other industries for expansion. If the reduced flow is still large enough to equip the released men with as much plant, machinery, and materials as those already at work in other industries, there will be little difficulty

Table I

EMPLOYEES IN NONAGRICULTURAL INDUSTRIES
1950-1961
(data in thousands)

	1950	1961
Total	45,222	54,076
Mining	901	667
Contract construction	2,333	2,760
Manufacturing	15,241	16,268
Transportation and public utilities	4,034	3,923
Wholesale and retail trade	9,386	11,365
Finance, insurance, and real estate	1,919	2,748
Service and miscellaneous	5,382	7,514
Government	6,026	8,831

Source: U.S. Bureau of the Census, *Statistical Abstract of the United States, 1962* (Washington: U.S. Government Printing Office, 1962).

in absorbing the men at current wage levels. If, however, the reduced capital flow is inadequate, the men will not be absorbed unless wage rates fall.

The effect of a small flow of capital on expansion and employment as compared with a large flow is highlighted by employment experience between 1929 and 1938 as compared with that between 1946 and 1955. In the 1929-38 period, net saving and capital formation equaled 2.5 percent of the net national product.[1] In face of a 35 percent rise in real wage rates (from $0.77 to $1.04 hourly earnings in manufacturing[2] measured in 1947-49 dollars), all the new capital and more was absorbed equipping men at work with the consequences that employment fell by three million (from 47.6 million in 1929 to 44.2 million in 1938).[3]

In the 1946-55 period, net saving and capital formation equaled 9.0 percent of the net national product. Despite the 26 percent rise in real wage rates (from $1.30 to $1.64 hourly earnings in manufacturing measured in 1947-49 dollars), the new capital was sufficient to equip the men at work with additional capital with enough left over to expand capacity by an amount great enough to increase the number of civilian jobs by eight million (from 57.5 million to 65.8 million).

Thus, in summary, the employment and wage consequences of newly invented automation techniques which reduce labor requirements per unit of product depend upon the responsiveness of demand to price decreases (elasticity of demand) and the flow of savings available for investment. If demand is very responsive, no difficulty should occur. If it is not very responsive, no difficulty need occur if the flow of savings is large enough. Only unresponsive demand and a low flow of savings will result in unemployment or, alternatively, reduced wage rates.

---

[1] S. Kuznets, *Capital in the American Economy* (Princeton: Princeton University Press, 1961), p. 95.

[2] *The Economic Almanac: 1960* (New York: National Industrial Conference Board, 1960), p. 255.

[3] *Economic Report of the President* (Washington: U.S. Government Printing Office, 1961), p. 146.

The selected instances of automation described above do not cover all the various types.[4] They represent extreme cases which illustrate the spectrum and indicate possible consequences. In any given instance, the results cannot be predicted simply from an analysis of the technique itself. The same newly applied technique will have different consequences depending upon the response of the market for the product, the nature of the labor market, the rate of growth of the labor force, and the flow of savings available for investment. In general, the larger the flow of savings, the less the difficulties created by automation. Also, the more flexible or free labor markets are, the fewer the difficulties and strains encountered.

[4] Y. Brozen, "The Economics of Automation," *American Economic Review*, May 1957.

SHORT-RUN ADAPTATION TO AUTOMATION

IT IS FREQUENTLY POINTED OUT that automation has created more jobs than it has destroyed. Nevertheless, while some people find jobs at higher wages because of automation than they otherwise would be able to obtain, others are displaced and may suffer extended periods of unemployment. What is the magnitude of this displacement? How can we minimize it without deleterious effects upon the economy? How can we shorten the period of unemployment of those who are displaced? And are those seeking a job for the first time adversely affected?

Before discussing the displacement problem, we must understand that there has been no unemployment caused by technological change.[1] Although some people are unemployed who would have been at work but for automation, others are at work who would have been unemployed but for the same automation. "The real impact of automation on unemployment is this: jobs are lost in one plant, in one industry, or in one locality, while they are created somewhere else—in another plant, another industry, and another locality."[2] What automation does is to change *who* is unemployed, but it does not increase unemployment. Automation has caused displacement, but not unemployment, at least in the sense of increasing the total number unemployed. If anything, it has decreased the total number unemployed.[3]

The Magnitude of Displacement

Expenditures for new plant and equipment by United States business amount to about $36 billion per year. Although our data are not adequate for precise estimates, it appears that approximately 60 percent of this spending goes for modernization and the balance for expansion. If all the modernization investment displaces men, about 600,000 men per year would be displaced.

Many of the companies modernizing their plants are, at the same time, expanding capacity. The number of new jobs now being created by the expansion of capacity is approximately one million per year. If the new jobs are created in the same plants that are modernizing, the men who would have been displaced

---

[1] Y. Brozen, "Automation: Creator or Destroyer of Jobs," *Iowa Business Digest,* February 1956.

[2] E. Clague, *Automation and Unemployment* (U.S. Department of Labor, September 29, 1961, mimeographed).

[3] Other factors are responsible for the unemployment attributed to automation. For a discussion of these other factors, see Y. Brozen, "Why do we have an Unemployment Problem," *Employment and Unemployment, The Problem of the 1960's* (Washington: Chamber of Commerce of the United States, 1961).

often can be shifted to the new jobs and no employee finds himself without a job because of displacement.

Unfortunately, expansion investment frequently occurs in companies and plants different from those that are modernizing. Some men, then, are laid off. No estimate is available of the number of men actually laid off because of automation. About the best we can do, estimating on the basis of isolated instances which may or may not be representative, is to say that the amount of actual layoffs is considerably less than 200,000 per year. These appear to be concentrated in a few industries such as coal mining, railroading, and automobile manufacturing. The employment decline in coal mining has amounted to 20,000 per year. In railroading, it has amounted to 40,000 per year, and in auto manufacturing about 10,000 per year.

The number of men permanently laid off in an industry is, of course, much less than the decline in total employment. Much of the decline occurs through retirements and voluntary quits. Some industries in which employment is declining still have to hire men each year because retirements and quits exceed the decline.

Even in the automating industries in which employment is declining, it cannot be said that the employment decline is the result of automation. In railroading and coal mining, the employment decline would have been much greater, given the increases in wage rates which occurred, but for automation. The reduction in costs resulting from automation made it possible to retain markets which would have been lost to trucks, buses, pipelines, barges, and airlines in the case of railroads and to oil, gas, water power, and atomic energy in the case of coal mines. By retaining these markets, railroads and coal mines are providing more jobs than would have been available if they had not been able to minimize, through automation, their rise in costs and prices.

Both rail transportation and coal mining have suffered extraordinary increases in employment costs. Aside from substantial

increases in fringe benefits, hourly earnings in coal mining rose from $1.20 in 1945 to $3.15 in 1960. This was a greater proportionate rise than in manufacturing, which rose from $1.02 to $2.26. The differential relative to manufacturing increased from 18 percent to 39 percent, shifting 21 percentage points, a rise of over 100 percent in the percentage differential. One of the results was a decline in coal mining jobs from 384,000 to 168,000. Rail wage rates and employment show the same pattern. Hourly earnings rose from $0.96 to $2.61, again with a shift of 21 percentage points in the differential relative to manufacturing. Here, too, the number of jobs declined, from 1,400,000 to 800,000.

If rail and coal wage rates had maintained the same relationship to manufacturing wage rates throughout this period, the decline in employment, undoubtedly would have been much smaller. Thus, at 1960 output levels, coal mining employment would have been about 80,000 higher than it was, and rail employment would have been approximately 450,000 higher. In addition, rail tariffs and coal prices probably would have been lower and sales and output higher. Additional jobs would have been created by the larger output.

The Location of Displacement

Usually, layoffs because of automation occur when the automation and any employment decline are concentrated in one area while expansion is occurring in other areas. For example, 41,000 more men were employed in Michigan in the transportation equipment industry than in the other East North Central states in 1954. By 1958, Michigan's transportation equipment employment had dropped to 44,000 less than in the other East North Central states.

Michigan has suffered a much higher incidence of unemployment than most other states. This occurred because of the much greater decline in auto employment there, and the greater concentration of the auto industry in Michigan, than that in other states. It would be easy to blame unemployment in Michigan

on automation, except that auto industry automation seems to have had a different result in Michigan than elsewhere. In seeking a reason for this, we find that transportation equipment wage rates rose 10 percent more in Michigan than in other East North Central states between 1950 and 1957. Primarily, this led to the adaptive response described above.

Dr. Stephen Sobotka has analyzed the underlying relationships which explain the Michigan phenomenon.[2] He found that a 1 percent rise in relative wage rates in the transportation equipment manufacturing industry reduces employment in this industry by 2.8 percent. Employment decreases by this amount if the industry holds its output constant in spite of its cost increases. If the cost increases cause lower output, an even greater decrease in employment occurs.

The saving in manpower is purchased at the price of heavy capital expenditures. Increasing labor costs in Michigan have twisted capital allocation in the direction of modernization and away from expansion of capacity. The result has been a declining use of labor, notwithstanding large expenditures on equipment and plant, although such large expenditures in other states are accompanied by increased employment.

The point can be made clear by an illustration. Assume that an investment of $15,000, which is equivalent to an annual expenditure of $3,000, let us say, will create one job at prevailing wage rates. With, let us assume $1,200,000 available for investment in Michigan, additional capacity will be built which will return $240,000 per year to cover annual capital costs (corporate earnings tax, property tax, and return to security holders sufficient to induce investment). The additional capacity will provide 80 additional jobs.

Now, let us suppose that in Michigan 1,000 men are employed at $6,000 per year in an industry in which the elasticity of substitution is −2.8. This elasticity is based on the condition that

[2] S. Sobotka, "Michigan's Employment Problem: The Substitution Against Labor," *Journal of Business,* April 1961.

28 of the men can be replaced, with no reduction in output, with equipment whose annual cost is, let us say, $169,000. Since the 28 men cost $168,000 annually (28 times $6,000), there is no incentive to replace them. However, a *relative* wage increase (or employment cost increase) of 1 percent raises employment cost for the 28 men (in terms of a constant dollar) to $169,680. It now pays employers to use capital for replacement of men, since the annual cost of $169,000 for equipment (investment required equals $845,000), indicates that the capital can earn more by replacing labor than it can by providing additional capacity. Then, of the $1,200,000 otherwise available in Michigan for creating additional jobs, $845,000 will go into manpower saving uses, and will reduce the number of present jobs by 28. Now only $355,000 of the $1,200,000 is left for enlarging capacity. Instead of 80 additional jobs, there will be only 23 to 24 additional jobs to absorb the 28 men displaced. Therefore, in spite of enlarged capacity and a growth in industrial activity, employment will fall.

Methods for Minimizing Displacements

The analysis of the Michigan situation points the way to methods of minimizing displacements. Less rapid increases in employment costs will divert less investment to modernization, and less displacement will occur.

Also, more investment will go into expansion if there is a slower rise in employment costs. Also, the expansion is more likely to occur in the locality of the modernization (automation). In these circumstances, men may be directly transferred to the new jobs without suffering displacement and an extended interval of unemployment.

Even where the new jobs require new skills, employers generally have shown great willingness to undertake training programs to avoid laying off their employees. Bureau of Labor Statistics' studies of a petroleum refining plant and an insurance office, Bright's recountal of the events connected with the auto-

mation of an engine plant and an electric generator plant,[3] and Caples' account of the adjustments of the labor force when a continuous galvanizing line was substituted for pot operations, all indicate this.[4] One personnel director has reported that production workers in his company have been retrained because of job changes, on the average, six times in the past ten years.

In many instances where the new jobs available are not sufficient to absorb displaced workers, employers often still manage to meet the problem without discharging any employees. The decrease in labor requirements following technological changes is frequently met by not replacing retiring personnel and voluntary quits. Cases of this type have been described in the literature for conversions to electronic accounting and the automation of a bakery.[5]

Figure 1

WHEN ELECTRONIC DATA PROCESSING IS BROUGHT INTO A UNIT, JOBS ARE LOWERED MAINLY BY TRANSFER AND TURNOVER

DATA: DEPARTMENT OF LABOR, BLS SURVEY OF 20 BUSINESS OFFICES

[3] G. P. Shultz and A. R. Weber, "Technological Change and Industrial Relations," *Employment Relations Research* (New York: Harper & Brothers, 1960).

[4] *The Competitive Challenge to Steel* (New York: American Iron and Steel Institute, 1961), p. 3A.

[5] Shultz and Weber, *op. cit.*

Most employers extend themselves to avoid creating a displacement unemployment problem. Yet, employers, unions, and government are in large degree responsible for the overly rapid increase in employment costs in some industries and some areas which create a displacement problem.

Avoidance of displacement can also be accomplished by a higher rate of saving and investment, as well as by a less rapid rise in employment costs. If enough new capital were regularly available, the same wage increases would have less effect on total employment. A larger flow of savings could provide as much capital as employers find it economic to use for modernization and leave a larger amount for expansion. The greater expansion of capacity would serve to decrease the displacement occurring with any given employment cost increase. In this case, we could have our cake (higher wage rates) and eat it (no unemployment) too.

One most important measure to encourage increases in savings and investment would be revision in the tax laws removing the punitive rates on higher incomes and reducing corporate earnings tax rates, as well as business property taxes.

LONG-RUN ADAPTATION TO AUTOMATION

AUTOMATION, OTHER THAN adaptation to employment cost increases greater than those consistent with maintenance of full employment, increases productivity, and per capita income. Thus the analysis of the long-run adaptation to the consequences of automation is largely an analysis of the adaptation to rising productivity and per capita income.

We can understand better the adaptations required by first examining past responses to such circumstances. Past shifts in the relative importance of different types of industry and employment will yield significant clues as to what may be expected in the future.

The Shift in the Structure of Industry and Employment

The past century has seen a sharp decrease in the relative importance of the primary industries, i.e., the extractive industries (agriculture, forestry, fishing, and mining). In 1870, these industries employed more than one-half of our total work force. Thirty years later, at the turn of the century, primary industries still used over 40 percent of the work force. By 1930, the figure had dropped to less than 25 percent, and by 1960 these industries employed only 10 percent of the work force. It is expected that the figure will continue downward in the future.

On the other hand, the secondary or fabricating industries (manufacturing and construction) have employed proportionately more people every decade (see Table II). In 1870, one-fifth of our work force was in these industries. By 1900 the number had risen to one-fourth. The figure is now approaching one-third.

Table II

DISTRIBUTION OF WORK FORCE IN THE U.S., 1870

	1870	1900	1930	1960
1. Extractive industries	54.4%	41.3%	24.5%	9.9%
2. Fabricating industries	21.9	27.3	29.2	31.8
3. Specialization aiding industries	10.9	16.9	26.3	31.9
4. Personal service industries	10.3	10.5	13.1	15.2
5. Life enriching industries	2.6	3.9	7.0	11.1

Source: Data through 1930, U.S. Bureau of the Census, *Historical Statistics of the United States* (Washington: U.S. Goverment Printing Office, 1960), and G. J. Stigler, *Trends in Employment in the Service Industries* (Princeton: Princeton University Press, 1956). Data for 1960, *Survey of Current Business,* July 1961.

The changing proportion of the work force employed in these two industries can be traced to differences in the income elasticities of demand for their products. As incomes increased, only a small part of the additional income was spent for agricultural commodities while a large part was spent for fabricated products. With each 1 percent increase in per capita income, the amount of agricultural commodities demanded grew less than one-half of 1 percent. The increases in per capita income were the result of increases in productivity. The extra 1 percent of agricultural output possible with the labor force in agriculture after productivity increased was met with a less than one-half percent increase in demand. In these circumstances, agricultural prices tended to fall.

On the other hand, the extra 1 percent of output possible from secondary industry with a 1 percent increase in productivity and per capita income was met with a 2 to 3 percent increase in demand. Fabricated product prices tended to rise. Manufacturers and construction companies found it profitable to bid for labor to meet the increased demand. Wage rates in the fabricating industries tended to rise relative to farm wage rates. People left farming to obtain the higher incomes available in manufacturing and construction.

The net effect of technological change in primary and secondary industry was a shift in the work force. The proportion of the work force required to meet a relatively static demand for primary products decreased and the proportion in secondary industry grew because of the growth in demand for fabricated products. With the increased incomes made possible by technical advances and other factors, people no longer had to spend such a large proportion of their budgets for food. The extra income went to buy more products. Further, it became possible to produce more of such products because the advance in farm productivity released people to fill jobs in fabricating industry.

Secondary industry now faces the same fate faced earlier by the primary industries. At the much higher levels of income now

enjoyed by residents of the United States, the income elasticity of demand for fabricated products is much lower than it once was. Just as people might be said to have had their fill of primary products and did not want much of the extra primary product which could be produced with the increased productivity of a given labor force, they now have their fill of secondary products and do not want much of the extra product which can be produced with the increased productivity of the fabricating work force. If the extra product made possible by higher productivity is to be sold, prices of fabricated products will have to fall and secondary wage rates be reduced (or rise less rapidly) or there will be a declining proportion of employment in the secondary industries. If secondary wage rates are not reduced, where will fabricating workers find employment?

Table III

PRIMARY AND NON-PRIMARY EMPLOYMENT
1850-1960
(in millions)

	Farm and other primary jobs	Non-primary jobs	Total employment
1850	5.12	2.58	7.70
1860	6.43	4.10	10.53
1870	6.69	6.23	12.92
1880	9.02	8.37	17.39
1890	10.65	13.09	23.74
1900	11.68	17.39	29.07
1910	12.64	24.09	36.73
1920	12.63	28.98	41.61
1930	11.46	35.94	47.40
1940	10.25	43.05	53.30
1950	8.70	53.70	61.40
1960	6.74	62.17	68.91

Source: *Economic Report of the President* (Washington: U.S. Government Printing Office, 1961); U.S. Bureau of the Census, *Historical Statistics of the United States* (Washington: U.S. Government Printing Office, 1960).

The fact that secondary demand is not growing as fast as productivity and income means that people must be spending their extra income for other goods. If increases in incomes are not being devoted to the extra primary and secondary goods that can be produced with increased productivity, where is the extra income going?

SOURCES: (See attached table)

Figure 2

In recent years, it has become apparent that we have reached levels of income at which very high income elasticities of demand for the products of personal service and life-enriching industries prevail. The growth in demand for beauty shop services, and for education, entertainment, travel, research, and medical services has increased employment opportunities in the fourth and fifth categories (see Table II). In education, an industry falling in the life enrichment group, employment has more than doubled in the last 30 years. The same thing has occurred in

medical and other health services. Some of the growth in the third category is in part a result of activities grouped there which are fourth and fifth category in character. Restaurants are included in trade (a third category, specialization aiding industry) by the census takers although they provide personal service. Radio and television are included in transportation, public utility, and communication (also a third category group), although they chiefly entertain and inform, a fifth category activity.

The impending relative decline in employment in manufacturing will be as much a result of workers being attracted away from this group of industries as it is of labor-saving inventions. As people grow wealthier and spend more of their time and incomes upon services, leisure and recreational activities, and use more medical and educational services to lead healthier and fuller lives, employment opportunities in these areas will expand even more rapidly than primary and secondary employment contract.

Within the secondary industries, there will be shifts in structure and in occupational mix. Those secondary industries which provide goods used in the life enrichment industries or as substitutes for personal services will grow as others decline. The school furniture, textbook, visual aids equipment, and pharmaceutical industries will wax as well as the outboard motor, ski equipment, boat building, and photographic film industry. Food processing has not declined despite the low income elasticity of demand for food because it has redesigned its product to incorporate a considerable amount of maid service, the demand for which has been frustrated by the rising price of domestic help.

The Shift in Occupational Structure

The occupational mix in the secondary industries is changing in response to automation and to the resulting higher wage rates of production workers. In one example of automation cited earlier, the number of production workers declined, but the number of maintenance people rose. As a general rule, automation tends to increase the ratio of maintenance to production

workers. Higher skill levels and more independent judgment are usually required for maintenance men. This will mean an increasing demand for such skills and will increase the yield from investment in skill acquisition.

In addition, the rising cost of production workers is leading to the employment of more indirect workers (production schedulers, personnel relations people, research and development personnel, design and factory layout engineers, salesmen, accountants, etc.) relative to production employees. Table IV shows the trend in such employment. The trend is an adaptive response to the increasing cost of production workers. Indirect workers are substituted for production people just as equipment is substituted for them as their cost rises.

In general, indirect workers require more education. Trends in the employment of maintenance and indirect workers not only in manufacturing, but also in other industries are in the direction of increasing job opportunities for those with more education and skill. Automation leads to an increasing demand for educa-

Table IV

Growth of Indirect Worker Employment In Manufacturing

Year	Total	Production workers	Indirect workers	Indirect workers as a percentage of total
	(thousands of persons)			
1942	15,051	12,854	2,197	14.5%
1946	14,461	12,105	2,356	16.2
1950	14,967	12,317	2,650	17.7
1954	15,995	12,589	3,406	21.3
1958	15,468	11,658	3,810	24.6
1961[a]	15,724	11,642	4,082	26.0

Source: *The Economic Almanac: 1962* (New York: National Industrial Conference Board, 1962).

[a] January-June average, seasonally adjusted.

tional services both because higher income persons spend more on education and because the return to investment in education increases.

Some indications of the return to investment in education are provided by the differences in lifetime earnings between people of various levels of educational attainment. In terms of the 1958 distribution of incomes, the lifetime earnings after age 25 of a male with less than eight years of schooling would be $121,000; those of an elementary school graduate $170,000; those of a high school graduate $242,000; and those of a college graduate $420,000.[1] The increasing value of education is shown by the relative changes in lifetime earnings at different levels. Thus between 1946 and 1958, an elementary school graduate's lifetime earnings increased by 70 percent while those of a college graduate rose by 109 percent.

Small Versus Large Business

The impact of technological change upon the scale of business and upon small versus large business is difficult to disentangle from all the other influences operating. Further, technical advances have had varying effects, some tending to reduce the minimum optimum scale and others tending to increase it. In terms of the more recent advances, automatic methods of manufacturing tend to increase scale while automated methods tend to decrease it.

The distinction between automatic and automated methods may be illustrated by alternative sets of home furnace controls. If burners in furnaces were controlled to heat their boilers for one hour every other hour, automatically turning on at the end of one hour and off at the end of the next, we would call this an automatic set of controls. With thermostats which sense the need, or lack of need, for burner operation to maintain a certain range of temperatures, the furnace is automated. It is operated

[1] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1961* (Washington: U.S. Government Printing Office, 1961).

by a device which senses what needs to be done and feeds the information to solenoids which control the burner.

Automatic machines can repeat a sequence of operations and stop themselves, but they cannot adjust readily to changing requirements. They are suited to long production runs of identical items, but require costly adjustment when different items are to be machined. For large volumes of identical products they are ideal, but are very costly when used on short production runs. "Detroit" automation is largely of this type.

Numerically controlled machine tools on the other hand, are economical on very short production runs. They can be adapted to changing requirements at very little expense. Control tapes can be prepared at low enough cost so that production runs of less than 100 units are as cheap as production runs of thousands on automatic tools.[2]

Therefore, the net results of automation cannot be forecast with certainty. Some of the new methods make small businesses more viable, others enable large organizations to operate with greater relative efficiency. Numerically controlled tools have the former effect; computerized data processing has the latter result.

In terms of the experience of the last ten years, the number of business firms does not appear to have been affected by the total of all influences operating, including technological change, in either direction. The total number grew by 17 percent between 1950 and 1962 (see Table V), approximately the same rate of growth as that of the total population. The very slow growth in the total of manufacturing employment was accompanied by a slight decline in the number of manufacturing firms. On the other hand, the rapid growth of employment in contract construction and the service industries has been accompanied by a rapid growth in the number of firms.

[2] *Automation and Technological Change: Hearings Before the Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report* (Washington: U.S. Government Printing Office, 1955).

Table V

Business Firms in Operation
(data in thousands)

	1950	1962
All industries	4,067	4,752
Contract construction	371	473
Manufacturing	321	318
Wholesale trade	266	326
Retail trade	1,816	2,022
Service industries	736	917
Other	543	696

Source: U.S. Bureau of the Census, *Statistical Abstract of the United States: 1962* (Washington: U.S. Government Printing Office, 1962).

CONCLUSIONS

THE TOTAL NUMBER of unemployed is lessened by automation although some of those who are among the unemployed would not be but for the new technology. Displacement through automation affects fewer people by far than seasonal swings in economic activity and shifts in consumer, governmental, and foreign demand. Nevertheless, the losses endured by the individuals affected tend to be more severe than those endured by individuals displaced by other employment changing factors. More older workers lose jobs and are unemployed longer as a result of automation.

In addition, younger workers find that special skills and higher educational attainment are becoming increasingly necessary to find jobs. In part, employers are tending to hire fewer less skilled, less educated people because of higher minimum wage rates set by laws, by governmental administrators, and by agreements, between unions and employers. At these rates, less skilled personnel are not sufficiently productive to justify employing. Adaptation to automation would be easier if the wage structure were less rigid. It could take place, then, by the acceptance of lower wage jobs by some individuals as well as by attaining higher skill levels.

Given our present wage structure, unemployment and loss of employment through displacement without readily available alternative jobs in the same region would be decreased through a higher rate of capital formation and economic expansion. This requires more saving. The income available for saving and the incentive to save and invest would be increased by reducing upper bracket income tax rates, corporate earnings tax rates, and business property taxes.[1]

Individuals can and are doing much of the adapting required within our present wage and tax structure by staying in school longer and by acquiring the special skills in demand. Further, many employers are providing retraining for a majority of their own employees directly affected by automation.[2] They are minimizing displacement by letting attrition of their work forces

[1] Wisconsin has moved this year to do this. A state sales tax shared by local governmental units has been enacted as a means of reducing property taxes on business.

[2] Also, a governmental program entitled "The Manpower Development and Training Act," approved March 15, 1962, authorizes a program for testing, counseling, and occupational training, including on-the-job training, for "those unemployed or underemployed persons who cannot reasonably be expected to secure appropriate full-time employment without training." The Act authorizes payment of training allowances for up to 52 weeks, and transportation and subsistence expenses when training is not provided within commuting distances of the trainee's home. It also authorizes agreements with the states under which they would utilize local facilities and provide training through public or private educational or training institutions.

take place through retirement and quits rather than layoff when the number of employees must be reduced. The amount of reduction could be minimized, however, if wage rate increases were less precipitate, particularly in regions already suffering abnormal levels of unemployment. In addition to minimizing displacement by use of normal attrition, separation allowances are frequently provided which the displaced employee can use to finance retraining or a move to better job markets.

The extended joblessness suffered by older workers sometimes is not mitigated by the acquisition of a new skill. There seems to be some unjustified prejudice against hiring those at upper age levels, although the evidence is not definitive on this point. Most evidence points to superior personal characteristics for the older worker, such as less absenteeism and greater ability to take responsibility, which makes him a desirable employee. Perhaps information on such characteristics needs publicizing. But even the older worker problem is much less severe when the economy is expanding rapidly.

The unemployment problem with which we are faced is not the result of automation and will not be worsened by automation. This new, and old, technology is spreading very slowly and the present slow pace is not likely to accelerate.

> The changes ahead will be gradual rather than abrupt. The chief [reason] is that it will take a considerable time to design and install the new plant that is needed for automatic operation. This delay will be increased by the impossibility of meeting immediately the huge demand . . . for electronic control equipment. Another detriment to rapid change will be the immense capital cost of installing new plant.
>
> The second reason for supposing a sudden shift to automatic production throughout industry to be most unlikely is the problem of education. We must reduce the current shortage of technologists and skilled technicians.
>
> Thirdly, . . . automatic production is . . . only applicable to some sections of industry.[3]

[3] Macmillan, *op.cit.*

APPENDIX

IF IT WERE NOT for technological change and growth in the stock of capital, employment would be approximately 20 million less than it now is and 13 million less than it was in 1951. The unemployment attributed to automation and to replacement of labor by machinery has been caused by the rise in wage rates. The average wage in manufacturing, for example, has increased from $1.79 per hour in 1951 to $2.32 per hour in 1961 measured in 1961 dollars and exclusive of fringe benefits.

The situation can be illustrated by examining a hypothetical economy with one product which sells for one dollar per unit. Suppose that there are 100 fully integrated firms. Each firm produces its own raw materials and its own equipment. Each maintains or replaces its equipment as it wears out with the result that its depreciation is exactly offset by its production of equipment for its own use each year. We will also assume that each firm knows its production schedule with complete certainty. The 1951 schedule for each firm is shown below:

1 man	6,000 units of product
2 men	11,600 " " "
3 "	16,900 " " "
4 "	22,000 " " "
5 "	27,000 " " "
6 "	31,200 " " "
7 "	35,200 " " "
8 "	38,700 " " "
9 "	41,700 " " "
10 "	44,000 " " "

If the wage rate and other employment costs amount to $4,000 per year, every firm will want to hire at least six men. Firms will be indifferent about hiring a seventh man. A seventh man will make a net addition of $4,000 worth of product. If a seventh man wants a job, a firm will be willing to use him, but it will not seek a man to fill the job. With 100 firms, there will be at least 600 men wanted to fill jobs although as many as 700 men can find employment at the $4,000 wage. If the number of men seeking jobs is 620 men, all will find employment.

Now let us suppose that the wage rate is increased to $5,000 per year. No firm will be willing to hire more than five men. A sixth man adds only 4,200 units of product to total output which is worth only $4,200. A firm would lose $800 hiring a sixth man at $5,000.

The increase in wage rate to $5,000 per year would cause employment to drop from 620 men to 500 men. Unemployment

would amount to 120 men. In terms of the magnitudes typical of the American economy, employment would drop from 62 million men to 50 million. Jobs would be destroyed by the wage increase.

In the discussion in this study, it was indicated that increased saving and investment would decrease unemployment. This point may be demonstrated using the situation outlined. With each plant employing five men, the wage bill would come to $25,000. Since total revenues are $27,000, there is a $4,000 return on plant investment (or slightly less than $2,000 after a 52 percent corporate income tax). If the investment required to build a plant is $50,000, a $2,000 after tax income would amount to a 4 percent return. Elimination of the corporate income tax would raise the return to 8 percent and would induce additional saving and investment. (It would also induce an inflow of foreign capital, reverse international gold flows, and reduce the necessity for a restrictive monetary policy to protect our stock of gold.)

Each new plant built, or each additional $50,000 saved and invested, would provide an additional five jobs at an annual wage of $5,000 each in the circumstances assumed here. With 120 men unemployed, the building of 24 new plants would provide enough jobs to eliminate the unemployment.

Some people argue that there is now excess plant capacity and therefore no use for additional capacity. They fail to realize that the capacity available was made excessive by the rise in wage rates. It was worth employing the 620 men who wanted jobs in the 100 plants with each plant using at least six men and producing at least 31,200 units of product when the wage was $4,000. With the wage at $5,000, it does not pay to operate a plant beyond 27,000 units of output. There is, then, an apparent excess capacity of at least 4,200 units in each plant. The capacity was made excess by the rise in real wage rates, not by a decline in demand.

Increased saving and investment will create additional jobs, and have done this in the past. Our employment difficulties lie in the fact that there has not been enough saving and investment to offset the rise in wage rates which has occurred.

Improved technology—automation—has done much to preserve jobs in spite of the increase in employment costs. Unemployment would be much greater if no technological change had occurred. This can be made clear by comparing the production schedule made possible by 1961 technology with that in a 1951 plant. The schedules are shown below.

	1951	1961
1	6,000	7,000
2	11,600	13,700
3	16,900	20,000
4	22,000	25,900
5	27,000	31,600
6	31,200	37,000
7	35,200	42,000
8	38,700	46,500
9	41,700	50,500
10	44,000	54,000

If the $4,000 wage rates of 1951 had remained unchanged to 1961, each 1961 type plant would employ at least eight people and possibly nine. With each 1961 plant requiring $50,000 of capital and there being 100 chunks of capital of this amount available in the form of 1961 plants, employment would amount to at least 800 men and could be as much as 900. In 100 1951 type plants employment at this wage would be at least 600 and possibly as much as 700. The creation of at least 200 new jobs can be attributed to the improved technology. A rise in the wage rate, to $5,000, restricts the number of positions employers want to fill to 600 and the maximum numbers of jobs men can find to 700. With this rise in wage rates, the number of jobs destroyed by the wage increase offsets the number created by automation (technological change).

SELECTED BIBLIOGRAPHY

"Automation–Bogeyman or Bonanza?," *Steel,* October 15, 1956.

Automation and Job Trends (Chicago: Council for Technical Advancement, 1955).

Yale Brozen. "The Economics of Automation," *American Economic Review,* May 1957.

Yale Brozen. "Studies of Technological Change," *Southern Economic Journal,* April 1951.

Yale Brozen. "Why Do We Have an Unemployment Problem?," *Employment and Unemployment, The Problems of The 1960's* (Washington: Chamber of Commerce of the United States, 1961).

Paul H. Douglas. "Technological Unemployment," *American Federationist,* August 1930.

H. B. Jacobson and J. S. Roucek, ed. *Automation and Society* (New York: Philosophical Library, 1959).

Joint Committee on the Economic Report. *Automation and Technological Change,* Report No. 1308 (Washington: U.S. Government Printing Office, 1956).

R. H. Macmillan. *Automation* (Cambridge: Cambridge University Press, 1956).

E. Schiff. *The Primary Employment Effects of Productivity Gains* (Chicago: Council for Technological Advancement, 1954).

U.S. Bureau of Labor Statistics. *Adjustment to the Introduction of Office Automation,* Bulletin No. 1276 (Washington: U.S. Government Printing Office, 1960).

U.S. Bureau of Labor Statistics. *Impact of Technological Change and Automation in the Pulp and Paper Industry,* Bulletin No. 1347 (Washington: U.S. Government Printing Office, 1962).

PUBLICATIONS

STUDIES

Essay on Apportionment and Representative Government, *Alfred de Grazia*–1963 ($2.00)

American Foreign Aid Doctrines, *Edward C. Banfield*–1963

The Rescue of the Dollar, *Wilson E. Schmidt*–1963

The Role of Gold, *Arthur Kemp*–1963

Pricing Power and "Administrative" Inflation–Concepts, Facts and Policy Implications, *Henry W. Briefs*–1962

Depreciation Reform and Capital Replacement, *William T. Hogan*–1962

The Federal Antitrust Laws, *Jerrold G. Van Cise*–1962

Consolidated Grants: A Means of Maintaining Fiscal Responsibility, *George C. S. Benson* and *Harold F. McClelland*–1961

Inflation: Its Causes and Cures, Revised and Enlarged Edition, *Gottfried Haberler*–1961

The Patchwork History of Foreign Aid, *Lorna Morley* and *Felix Morley*–1961

U. S. Immigration Policy and World Population Problems, *Virgil Salera*–1960

°Inflation: Its Causes and Cures, *Gottfried Haberler*–1960

Voluntary Health Insurance in the United States, *Rita R. Campbell* and *W. Glenn Campbell*–1960

Unionism Reappraised: From Classical Unionism to Union Establishment, *Goetz Briefs*–1960

United States Aid and Indian Economic Development, *P. T. Bauer*–1959

Improving National Transportation Policy, *John H. Frederick*–1959

The Question of Governmental Oil Import Restrictions, *William H. Peterson*–1959

Labor Unions and the Concept of Public Service, *Roscoe Pound*–1959

Labor Unions and Public Policy, *Edward H. Chamberlin, Philip D. Bradley, Gerard D. Reilly,* and *Roscoe Pound*–1958. 177 pp. ($4.50)

National Aid to Higher Education, *George C. S. Benson* and *John M. Payne*–1958

Agricultural Surpluses and Export Policy, *Raymond F. Mikesell*–1958

The Economic Analysis of Labor Union Power, *Edward H. Chamberlin*–1958

Post-War West German and United Kingdom Recovery, *David McCord Wright*–1957

The Regulation of Natural Gas, *James W. McKie*–1957

Legal Immunities of Labor Unions, *Roscoe Pound*–1957

°Automation–Its Impact on Economic Growth and Stability, *Almarin Phillips*–1957

°Involuntary Participation In Unionism, *Philip D. Bradley*–1956

The Role of Government in Developing Peaceful Uses of Atomic Energy, *Arthur Kemp*–1956

The Role of The Federal Government in Housing, *Paul F. Wendt*–1956

The Upper Colorado Reclamation Project, Pro by *Sen Arthur V. Watkins,* Con by *Raymond Moley*–1956

°Federal Aid to Education–Boon or Bane? *Roger A. Freeman*–1955

States Rights and the Law of Labor Relations, *Gerard D. Reilly*–1955

Three Taft-Hartley Issues: Secondary Boycotts, "Mandatory" Injunctions, Replaced Strikers' Votes, *Theodore R. Iserman*–1955

What Price Federal Reclamation? *Raymond Moley*–1955

°Out of Print.

Private Investments Abroad, *Charles R. Carroll*–1954

Farm Price Supports–Rigid or Flexible, *Karl Brandt*–1954

*Currency Convertibility, *Gottfried Haberler*–1954

The Control of the Location of Industry in Great Britain, *John Jewkes* –1952

The Walsh-Healey Public Contracts Act, *John V. Van Sickle*–1952

The Economics of Full Employment: An Analysis of the U.N. Report on National and International Measures for Full Employment, *Wilhelm Röpke*–1952

Price Fixing for Foodstuffs, *Earl L. Butz*–1951

Manpower Needs and the Labor Supply, *Clarence D. Long*–1951

An Economic Approach to Antitrust Problems, *Clare E. Griffin*–1951, ($1.00)

*Valley Authorities, *Raymond Moley* –1950

*Farm Price and Income Supports, *O. B. Jesness*–1950

*Monetary Policy and Economic Prosperity: Testimony of Dr. W. W. Stewart (July 3-4, 1930) before the Macmillan Committee with introduction by *Donald B. Woodward*–1950

Corporate Profits in Perspective, *John Linter*–1949

*Current Problems of Immigration Policy, *E. P. Hutchinson*–1949

Guaranteed Employment and Wage Plans. A Summary and Critique of the Latimer Report and Related Documents, *William A. Berridge* and *Cedric Wolfe*–1948

The Foreign Loan Policy of the United States, *J. B. Condliffe*–1947

*Proposals for Consideration by an International Conference on Trade and Employment, *J. B. Condliffe*– 1946

The Market for Risk Capital, *Jules I. Bogen*–1946

Unless otherwise shown in listing, Studies 1953 and earlier, 50 cents each; 1954 to date, $1.00 each.

LEGISLATIVE AND SPECIAL ANALYSES

87th Congress, Second Session, 1962

No. 1–The Proposal to Increase the National Debt Ceiling

No. 2–Reorganization Plan No. 1, of 1962 to Create a Department of Urban Affairs and Housing

No. 3–Foreign Trade: Part I: The Operation, Administration, and Development of the Trade Agreements Program. *A Special Analysis*

No. 4–Foreign Trade: Part II: Economic Consequences of Trade Liberalization. *A Special Analysis*

No. 5–Foreign Trade: Part III: Import Adjustment Assistance and Alternatives. *A Special Analysis*

No. 6–Foreign Trade: Part IV: The European Economic Community (Common Market). *A Special Analysis*

No. 7–Purchase of United Nations Bonds. Bill by *Sen. Sparkman*

No. 8–Foreign Trade: Part V: Proposals to Amend and Extend the Reciprocal Trade Agreements Legislation. *A Special Analysis*

No. 9–Proposals to Provide Health Care for the Aged Under Social Security. Bills by *Sen. Anderson, et al.; Rep. King*

No. 10–Tax Proposals Relating to Foreign Income. Bill by *Rep. Mills*

No. 11–Public Welfare Amendments of 1962. Bill by *Rep. Mills*

*Out of Print.

Publications

No. 12—The Drug Control Bills and Other Proposals to Amend the Food, Drug and Cosmetic Act. Bills by *Sen. Kefauver; Reps. Sullivan, Celler* and *Harris*

No. 13—The Proposed International Coffee Agreement. *A Special Analysis*

No. 14—The Pacific Northwest Power Preference Bills. Bills by *Sen. Anderson; Reps. Hansen* and *Pfost*

88th Congress, First Session, 1963

No. 1—History and Powers of the House Committee on Rules. *A Special Analysis.*

Single Copy One Dollar